Databases

Part 2/2
SQL

Kai Brünnler
CAS Applied Data Science
University of Bern

Material adapted from: Silberschatz, Korth, Sudarshan: Database System Concepts. 6th Edition.

Comparison Procedural vs Declarative

- Example: Find the name of the instructor with ID 22222

```
import csv

with open('instructor.csv') as file:
    reader = csv.DictReader(file)
    for row in reader:
        if row['ID'] == '2222':
            print(row['name'])
```

```
select  name
from    instructor
where ID = '22222'
```

Comparison Procedural vs Declarative

- Example: Find the building of the instructor “Einstein”

```
import csv

with open('instructor.csv') as file:
    reader = csv.DictReader(file)
    for row in reader:
        if row['name'] == 'Einstein':
            dept_name = row['dept_name']

with open('department.csv') as file:
    reader = csv.DictReader(file)
    for row in reader:
        if row['dept_name'] == dept_name:
            print(row['building'])
```

```
select building
from instructor, department
where instructor.dept_name =
      department.dept_name
      and
      name = 'Einstein'
```

DATA DEFINITION LANGUAGE (DDL)

Data Types

Basic Data Types

- **char(n)** Fixed length character string, with length *n*
- **varchar(n)** Variable length character string, with maximum length *n*
- **integer** Integer, size is machine-dependent
- **real** Floating point number, with machine-dependent precision.
- **numeric(p,d)** Fixed point number, with *p* digits before and *n* digits after the decimal point.

Large-Object Data Types

- Objects that are large (several kilobytes up to several gigabytes)
  - **blob** Binary large object: uninterpreted binary data
    - a photo or video
  - **clob** Character large object: a large string.
    - some text or an XML document.
- Queries return pointers to large objects, not the objects themselves

Create Table

- Example:

```
create table instructor (
        ID              char(5),
        name            varchar(20),
        dept_name       varchar(20),
        salary          numeric(8,2))
```

- Example with Integrity Constraints:

```
create table instructor (
      ID              char(5),
      name            varchar(20) not null,
      dept_name       varchar(20),
      salary          numeric(8,2),
      primary key (ID),
      foreign key (dept_name) references department)
```

DATA MANIPULATION LANGUAGE (DML)

The select Clause

- By default SQL lists duplicate tupels:

  select *dept_name*
  from *instructor*

  - To force the elimination of duplicates**:**

    select distinct *dept_name*
    from *instructor*

  - To retain duplicates (default):

    select all *dept_name*
    from *instructor*

- An asterisk denotes “all attributes”

  select *
  from *instructor*

- Can contain arithmetic expressions:

  select *ID, name, salary / 12*
  from *instructor*

Natural Join

- Natural join joins two tables in the natural way:
  - by combining all rows that have the same values on the common attributes.

- List the names of instructors along with the course ID of the courses that they taught:
  - **select** *name*, *course_id*
    from *instructor, teaches*
    where *instructor.ID = teaches.ID*;

  - **select** *name*, *course_id*
    from *instructor* **natural join** *teaches*;

Natural Join Example

- **select** * **from** *instructor* **natural join** *teaches*;

ID	*name*	*dept_name*	*salary*
10101	Srinivasan	Comp. Sci.	65000
12121	Wu	Finance	90000
15151	Mozart	Music	40000
22222	Einstein	Physics	95000
32343	El Said	History	60000
33456	Gold	Physics	87000
45565	Katz	Comp. Sci.	75000
58583	Califieri	History	62000
76543	Singh	Finance	80000
76766	Crick	Biology	72000
83821	Brandt	Comp. Sci.	92000
98345	Kim	Elec. Eng.	80000

ID	*course_id*	*sec_id*	*semester*	*year*
10101	CS-101	1	Fall	2009
10101	CS-315	1	Spring	2010
10101	CS-347	1	Fall	2009
12121	FIN-201	1	Spring	2010
15151	MU-199	1	Spring	2010
22222	PHY-101	1	Fall	2009
32343	HIS-351	1	Spring	2010
45565	CS-101	1	Spring	2010
45565	CS-319	1	Spring	2010
76766	BIO-101	1	Summer	2009
76766	BIO-301	1	Summer	2010
83821	CS-190	1	Spring	2009
83821	CS-190	2	Spring	2009
83821	CS-319	2	Spring	2010
98345	EE-181	1	Spring	2009

ID	*name*	*dept_name*	*salary*	*course_id*	*sec_id*	*semester*	*year*
10101	Srinivasan	Comp. Sci.	65000	CS-101	1	Fall	2009
10101	Srinivasan	Comp. Sci.	65000	CS-315	1	Spring	2010
10101	Srinivasan	Comp. Sci.	65000	CS-347	1	Fall	2009
12121	Wu	Finance	90000	FIN-201	1	Spring	2010
15151	Mozart	Music	40000	MU-199	1	Spring	2010
22222	Einstein	Physics	95000	PHY-101	1	Fall	2009
32343	El Said	History	60000	HIS-351	1	Spring	2010
45565	Katz	Comp. Sci.	75000	CS-101	1	Spring	2010
45565	Katz	Comp. Sci.	75000	CS-319	1	Spring	2010
76766	Crick	Biology	72000	BIO-101	1	Summer	2009
76766	Crick	Biology	72000	BIO-301	1	Summer	2010
83821	Brandt	Comp. Sci.	92000	CS-190	1	Spring	2009
83821	Brandt	Comp. Sci.	92000	CS-190	2	Spring	2009
83821	Brandt	Comp. Sci.	92000	CS-319	2	Spring	2010
98345	Kim	Elec. Eng.	80000	EE-181	1	Spring	2009

The Rename Operation – as clause

- Renaming attributes:

  select *ID, name, salary/12* **as** *monthly_salary*
  from *instructor*

- Renaming relations:
  - Find all pairs of instructors who have the same name:

    select *T.ID, S.ID*
    from *instructor* **as** *T, instructor* **as** *S*
    where *T.name = S.name*

String Matching – like clause

- Patterns are strings containing:
  - percent (%). Matches any substring.
  - underscore (_). Matches any character.

- Example:

select *name*
from *instructor*
where *name* **like** '_ _ _%stein%'

that has stein in them and at least 3 characters before

Ordering – order by clause

- List names in alphabetic order:

  select distinct *name*
  from *instructor*
  order by *name*

- Specify **desc**ending order, **asc**ending order is default:

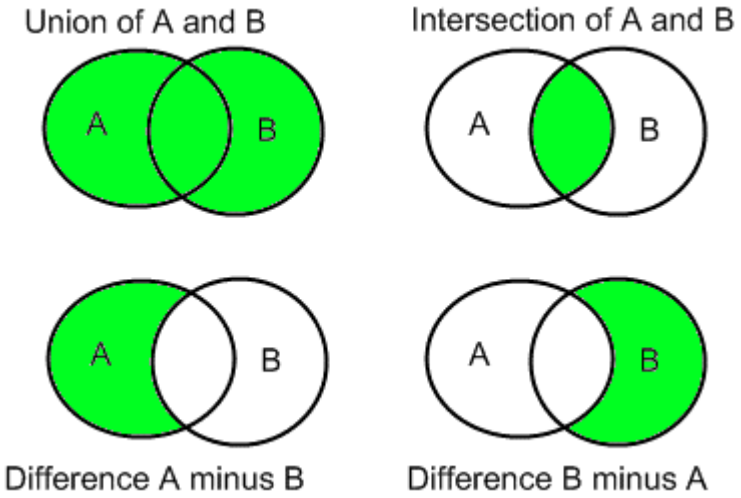
  order by *name* **desc**

- Sort on multiple attributes:

  order by *dept_name asc, name desc*

Set Operations: union, intersect, except

Keyword in SQL	Set Operation
union	union
intersect	intersection
except	difference



- Find courses that ran in 2009 or in 2010 or both:

  select *course_id* **from** *section* **where** *year* = 2009
  union
  select *course_id* **from** *section* **where** *year* = 2010

- Set operations eliminate duplicates
- To retain duplicates use **union all, intersect all** and **except all**

Null Values

- Null values are unknown or non-existent values
  - The result of any arithmetic expression involving *null* is *null*
  - A comparison with *null* returns the special boolean value *unknown*
  - The **where** clause treats *unknown* as *false*

5 == null? --> unknown

- What's the result of this?

  select *name*
  from *instructor*
  where *salary = null*

name	salary
Einstein	80000
Katz	null
Mozart	0

- Null values are very problematic.
  - Check for null with **is null** not "= null"
  - Always consider the possibility that a value is null.

Aggregate Functions

- Find the average salary of instructors in the Computer Science department
  - **select avg** (*salary*)
    from *instructor*
    where *dept_name*= ’Comp. Sci.’;

rows

- Find the number of tuples in the *course* relation
  - **select count** (*)
    from *course*;

- Find the number of instructors who taught a course in 2010
  - **select count** (**distinct** *ID*)
    from *teaches*
    where *year* = 2010;

Aggregate Functions – Group By

- Find the average salary of instructors in each department
  - **select** *dept_name*, **avg** (*salary*) as avg_salary
    from *instructor*
    group by *dept_name*;

ID	*name*	*dept_name*	*salary*
76766	Crick	Biology	72000
45565	Katz	Comp. Sci.	75000
10101	Srinivasan	Comp. Sci.	65000
83821	Brandt	Comp. Sci.	92000
98345	Kim	Elec. Eng.	80000
12121	Wu	Finance	90000
76543	Singh	Finance	80000
32343	El Said	History	60000
58583	Califieri	History	62000
15151	Mozart	Music	40000
33456	Gold	Physics	87000
22222	Einstein	Physics	95000

dept_name	*avg_salary*
Biology	72000
Comp. Sci.	77333
Elec. Eng.	80000
Finance	85000
History	61000
Music	40000
Physics	91000

Nested Queries

- A **subquery** is a query inside another query.
- There are three kinds of subqueries:
  - in the where-clause,
  - in the from-clause,
  - scalar subqueries (that can occur anywhere).

Subquery in the Where-Clause – in

- Find courses offered in 2009 and in 2010

```
select distinct course_id
from section
where year = 2009 and
course_id in (      select course_id
                    from section
                    where year = 2010 );
```

necessary because one course is represented on one line ("2009 and 2010" wont work, as this would have to be in one line, which is impossible)

Subquery in the Where-Clause – exists

- **exists** *r* returns **true** iff *r* is nonempty.

- Find all courses taught in both 2009 and 2010

```
select course_id
from section as S
where year = 2009 and
        exists (select *
                from section as T
                where year = 2010 and S.course_id = T.course_id);
```

  - S is a **correlation variable** the inner query references the outer query --> much more difficult to understand than on the slide before
  - the inner query is a **correlated subquery**

subquery is not eecutable by itself here

Scalar Subqueries

- A **scalar subquery** is a subquery which is used where a single value is expected
  - If it returns more than one tuple it causes a runtime error

- Find the instructors that cost more than 10% of their departments budget:

```
select name
from instructor
where  salary * 10 >
        (select budget  from department
          where department.dept_name = instructor.dept_name)
```

Deletion

- Delete all instructors

  delete from *instructor* ;

- Delete all instructors from the Finance department

  delete from *instructor*
  where *dept_name*= ’Finance’;

- Delete all tuples in the *instructor* relation for those instructors associated with a department located in the Watson building.

  delete from *instructor*
  where *dept_name* **in** (**select** *dept_name*
  from *department*
  where *building* = ’Watson’);

Deletion

- Delete all instructors whose salary is less than the average salary of instructors

  delete from *instructor*
  where *salary* < (**select avg** (*salary*) **from** *instructor*);

- Problem: as we delete tuples, the average salary changes
- Solution used in SQL:
  - First, compute avg salary and find all tuples to delete
  - Only then delete all those tuples

one after the other --> otherwise it would constantly update average salaries

Insertion

- Add a new tuple to *course:*

  insert into *course* only relying on the order of the columns
  values (’CS-437’, ’Database Systems’, ’Comp. Sci.’, 4);

- or equivalently:

  insert into *course* (*course_id*, *title*, *dept_name*, *credits*)
  values (’CS-437’, ’Database Systems’, ’Comp. Sci.’, 4);

- Add a new tuple to *student* with unknown *tot_creds:*

  insert into *student*
  values (’3003’, ’Green’, ’Finance’, *null*);

Insertion

- Add all instructors to the *student* relation with tot_creds set to 0

```
insert into student
    select ID, name, dept_name, 0
    from   instructor
```

- The **select** statement is evaluated fully before any of its results are inserted, the following is possible:

```
insert into student
  select *
  from student;
```

primary key restraints will prevent this

Updates

- Increase salaries of instructors by 5%:
  update *instructor*
  set *salary* = *salary* * 1.05;

- Problem: How to increase salaries of instructors whose salary is over $100,000 by 3%, and all others by 5%?
  - Write two **update** statements?

```
update instructor
    set salary = salary * 1.03
    where salary > 100000;
update instructor
    set salary = salary * 1.05
    where salary <= 100000;
```

one is executed after the other --> potentially a double raise for somebody

Updates – case statement

- Problem as before, solution with case statement:

```
update instructor
   set salary =
         case
            when salary <= 100000 then salary * 1.05
                                  else salary * 1.03
         end
```